MINING METHODS AND PRACTICES AT THE JOHNSON CAMP COPPER-ZINC MINE, CORONADO COPPER & ZINC CO., COCHISE COUNTY, ARIZ.

BY W. R. HARDWICK AND JOE SIERAKOSKI

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W. R. Hardwick[1/] and Joe Sierakoski[2/]

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SUMMARY AND INTRODUCTION

This paper, which describes mining methods and practices at the Johnson Camp copper-zinc mine, Coronado Copper & Zinc Co., Cochise County, Ariz., is one of a series being prepared by the Bureau of Mines on mining methods, practices, and costs in various mining districts of the United States.

Johnson Camp is in the eastern foothills of the Little Dragoon Mountains in secs. 23, 24, 25, and 26, T. 15 S., R. 22 E. (fig. 1). The mining property is in the low, rolling foothills at an altitude of slightly over 5,000 feet above sea level (fig. 2). The area is covered with scattered grass and small desert shrubs. The climate is mild, with hot summers and mild winters. The average annual precipitation is about 12 inches. The nearest surface water is the San Pedro River, some 12 miles west of the mine. The property is owned by the Coronado Copper & Zinc Co., Los Angeles, Calif.

This report gives a brief history of the property, describes the general geology of the area and of the ore deposits, outlines the methods of prospecting and exploration, and gives the methods of sampling and of estimating ore reserves. Development and stoping methods are explained. Underground transportation, ventilation, mine drainage, and safety measures also are described. The last section gives a brief description of the milling practice.

ACKNOWLEDGMENTS

Acknowledgment is made to the executives and staff of the Coronado Copper & Zinc Co. for permission to publish this paper. Special acknowledgment is due Fred E. Gray, mine manager, and Max Daugherty, mine foreman, for their valuable assistance and cooperation. Maps were furnished by the Coronado Copper & Zinc Co.

HISTORY[3/]

Copper ore was discovered in the Johnson Camp area of the Cochise or Dragoon mining district, Cochise County, Ariz., before 1881. In 1882 the Russell Gold & Silver Mining Co. of Philadelphia constructed a small smelter at Russelville and began smelting ores from the district. This smelter was moved to the Peabody mine in 1883 but soon was closed and the mine shut down. In 1899 the Peabody mine was reopened by the Dragoon Mining Co., a subsidiary of the Federal Copper Co. of New York. The Dragoon Mining Co. is said to have failed in 1903, but the Peabody mine was operated intermittently until 1918 by the Bonanza Belt Copper Co., then by the Peabody Consolidated Copper Co.

3/ Cooper, John R., Johnson Camp Area, Cochise County, Ariz., chap. III, Arizona Zinc and Lead Deposits, Part I: Ariz. Bureau of Mines Bull. 156, April 1950, pp. 30-31.

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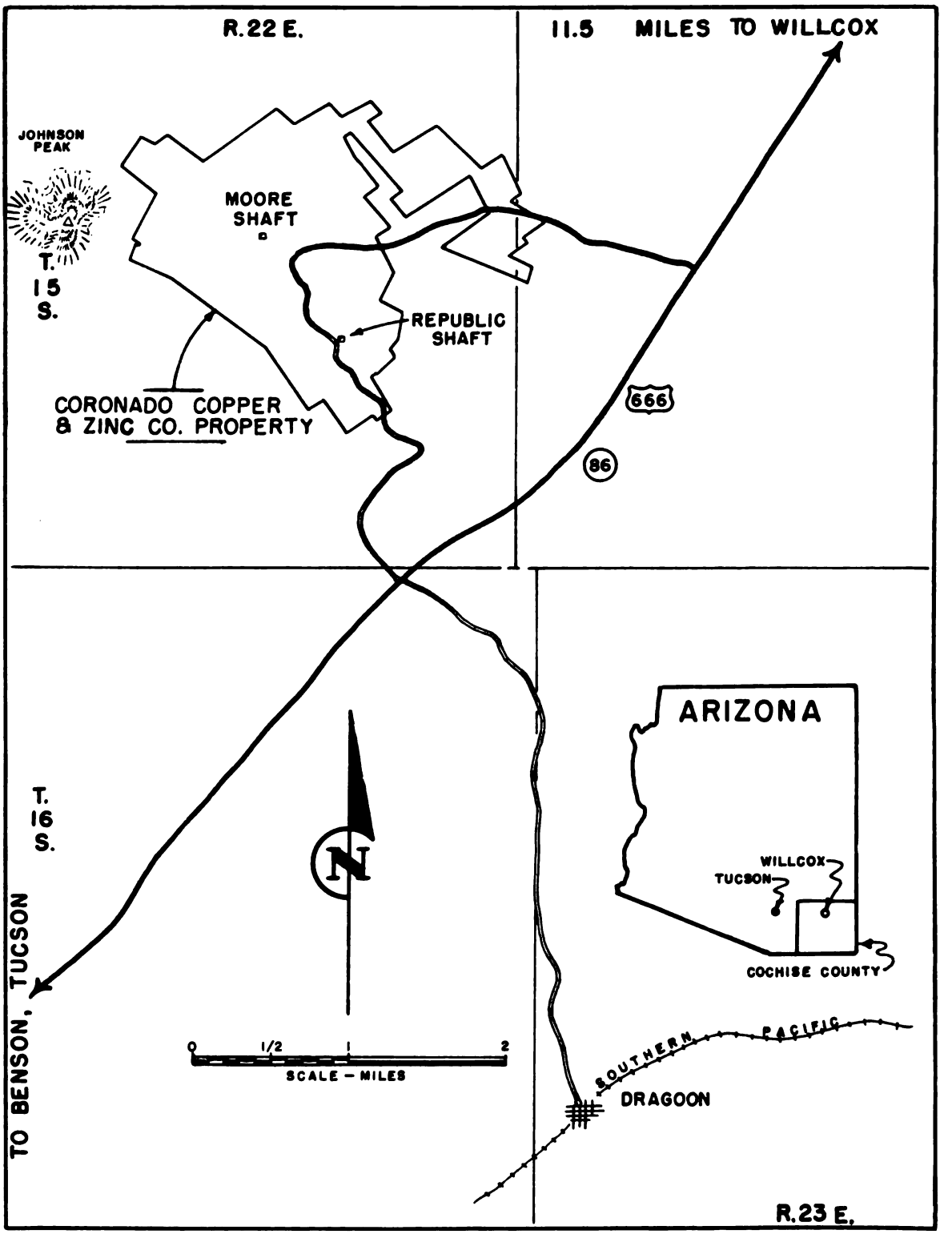

Figure 1. - Location map—Johnson Camp unit, Coronado Copper & Zinc Co., Cochise County, Ariz.

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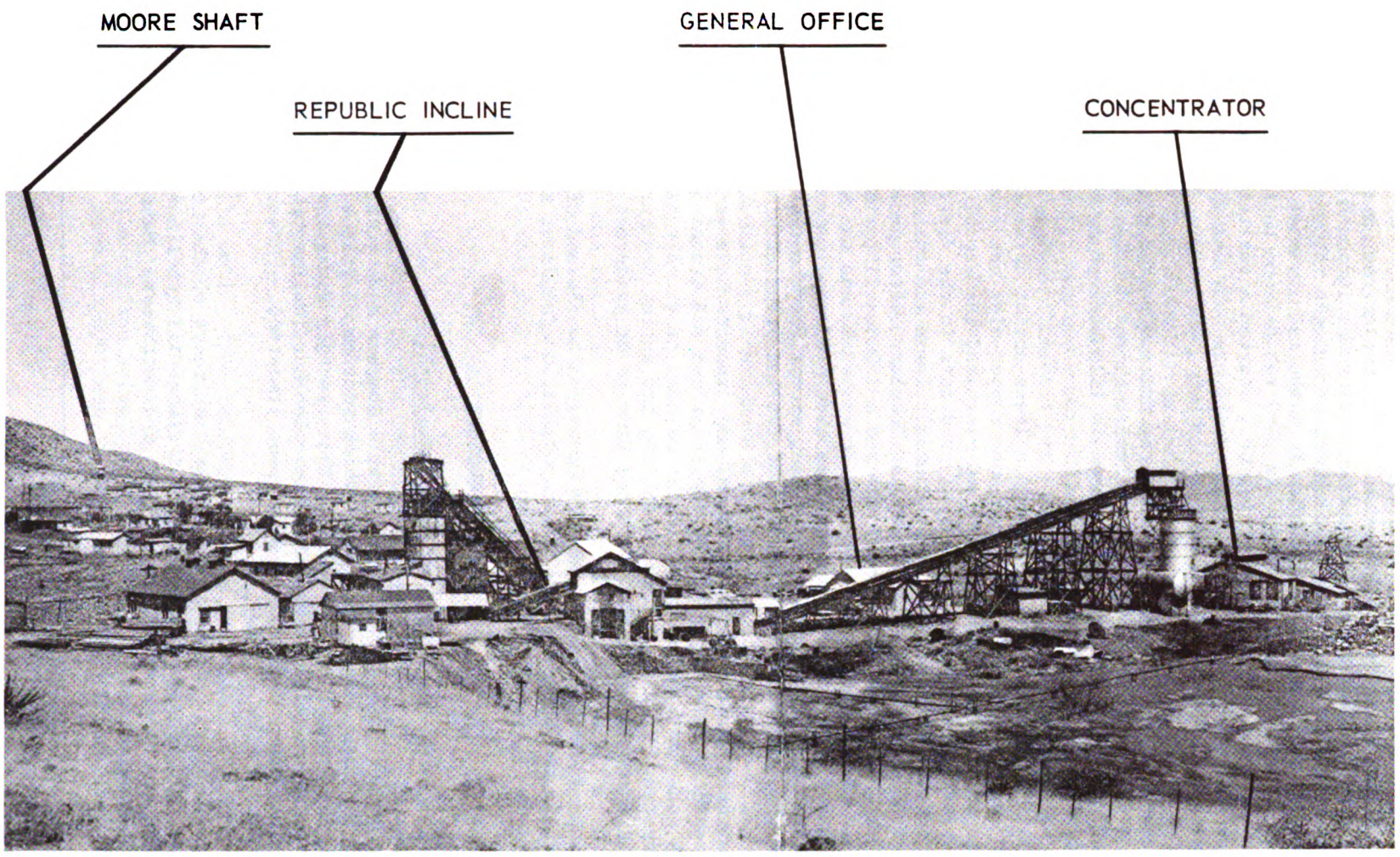

Figure 2. - General view, Johnson Camp.

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In 1901 the Black Prince Copper Co. began exploration work in the district. Four years later the Arizona Consolidated Mining Co. reopened the Republic and Mammoth mines, and the Michigan Development Co. bought the Copper Chief mine. In 1906-08 a railroad spur was constructed from the main line of the Southern Pacific Railroad at Dragoon to Johnson Camp. In 1909 the Arizona United Mining Co., the reorganized Arizona Consolidated Mining Co., started a smelter at the Republic mine but soon abandoned it. In 1912 the Main Manto ore body was discovered at the Republic mine.

A mining boom started in 1914 when the Arizona United Mining Co. and the railroad from Dragoon to Johnson Camp were leased by the Cobriza Mines Development Co. However, all mines in the district closed in 1920 because of the low price of copper, and they remained inactive until 1941.

In 1941 William A. Hooton obtained a lease-option agreement from the owners, Roy Wilson and Samuel Traylor, and shipped copper-zinc ore from the Republic mine. Before this date, Wilson and Traylor had purchased the Republic, Mammoth, Copper Chief, and Peabody mines; the principal producers in the district. In 1942 the Coronado Copper & Zinc Co. took over Hooton's lease and option and later purchased the consolidated property from Wilson and Traylor. After proving a substantial amount of ore, the Coronado company erected a 150-ton flotation plant, which was completed in 1945. Later, the Moore shaft was sunk, and the Moore ore body was developed. Since that date the company has been producing copper-zinc ore, making a copper concentrate and a zinc concentrate, except for about a year from 1949 to 1950, when the mine was closed because of the low price of zinc.

Since their discovery, the Johnson Camp deposits have been worked intermittently, production rising with high copper prices and stopping during times of low prices. A peak was reached in the eighties when relatively high grade oxide ores were discovered. High production also resulted during the First World War. Since 1941 a fairly steady production has come from lower grade ore.

Total production from the Johnson Camp area to the end of 1955 has been approximately 53,473,400 pounds of copper and 60,205,500 pounds of zinc, with some lead and silver.

GEOLOGY

General Geology[4/]

The oldest rocks exposed in the Little Dragoon Mountains are the Precambrian Pinal schist and the Apache group. A thick section of Paleozoic rocks lies unconformably upon these older formations. These younger formations consist of Cambrian Bolsa quartzite and Abrigo formation, Devonian Martin limestone, Mississippian Escabrosa limestone, and Pennsylvanian Naco limestone. These are overlain by the Lower Cretaceous Bisbee group.

After deposition of the Bisbee group, the rocks of the Little Dragoon area were folded into a broad dome with smaller anticlines and synclines at its southern and southwestern end, these folds trending to the northwest. Many faults were formed during this same period.

4/ Work cited in footnote 3, pp. 31-35.

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After this regional folding and faulting a large body of quartz monzonite was intruded into the southeastern part of the dome, cutting rocks as young as the Lower Cretaceous. Later dikes of aplite and lamprophyre cut the monzonite and surrounding rocks. The Johnson Camp ore bodies are related to this monzonite intrusive cycle, although the deposits are in the limestone 1/4 to 1-1/2 miles from the main intrusive mass.

The Johnson Camp area is cut by at least three well-defined sets of faults and fractures. The best defined set, the Northeasters, strikes from N. 5° to 30° E. and dips from 60° to 80° southeasterly; a second less well defined set, the Easters, strikes N. 60° to 90° E. and dips 30° to 60° southerly; a third relatively unimportant group, the Northwesters, strikes from N. 10° to 45° W. and dips steeply either southwest or the northeast. Most of the faults are normal with the east or south sides being downthrown. Displacements range from almost zero to 1,000 feet. Many were formed before the mineralization period although some movement has taken place after that time.

Ore Deposits

The ore bodies in the Johnson Camp area occur in limestone beds in the lower part of the thick Paleozoic section; these beds dip 20° to 45° northeasterly (fig. 3). The Cambrian Abrigo limestone is the most productive formation, with the Pennsylvanian Naco limestone second. The ore bodies occur at or near the intersection of mineralized fractures (usually Northeasters or Easters) with these beds and along anticlinal flexures in the beds. Some ore bodies are irregular tabular deposits parallel to the beds, 3 to 15 feet thick and several hundred feet across. The largest ore bodies are chimney-type and more or less oval in cross section, with the long axis in the plane of the beds. The largest one, the Main Manto, was found at the Republic mine; it was 1,500 feet long, 30 to 100 feet wide and 15 to 40 feet thick.

The primary ore consists of varying amounts of chalcopyrite, sphalerite, and bornite, with pyrite and small amounts of molybdenite and scheelite. The gangue is composed of lime-silicates (mostly garnet, diopside, and epidote), potash feldspar, quartz, and calcite. The ratio of zinc to copper is variable. At present the ore averages approximately 2.10 to 2.80 percent copper and 4.5 to 5.2 percent zinc.

PROSPECTING AND EXPLORATION

Diamond drilling from the surface has been the exploration technique generally used in the Johnson Camp area by the Coronado Copper & Zinc Co. Flat-raking ore bodies are discovered by this method, notably those in the Moore shaft area. Important chimney-type ore bodies commonly end abruptly on both sides; therefore close spacing of diamond-drill holes is essential for adequate coverage of the target area. Surface drilling is augmented by underground diamond drilling from strategically located drifts and workings.

The ground drills well. Core recovery is high. On the surface an AX size bit is used until broken surface ground has been passed, usually from 100 to 150 feet, then the hole is cased and finished with an EX size bit. Surface drilling is contracted. Underground holes are drilled with 1 or 2 company-owned machines on company account. Over 146 surface holes and 300 underground holes have been drilled for a total of more than 115,000 feet of drill holes.

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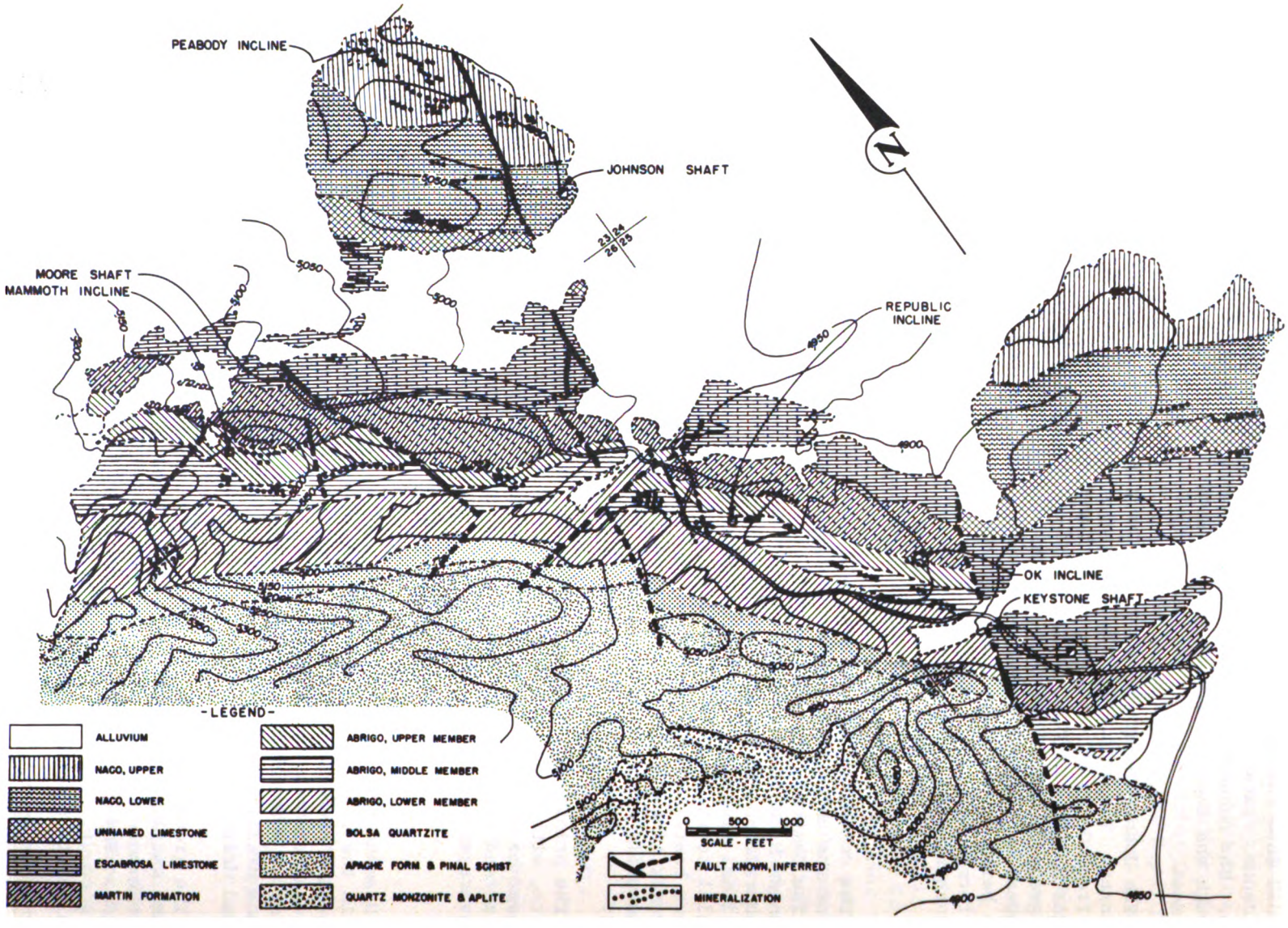

Figure 3. - Geology of Johnson Camp district. *(Courtesy, Coronado Copper Co.)*

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After diamond drilling has indicated an ore body, exploration headings are driven to prospect the favorable ore horizon and to provide drill stations from which to prove the ore indications further. This is done by drilling enough drill holes through the ore body to outline its shape. Because many of the ore bodies are small, prospecting is carried on almost continuously.

No regular drilling pattern is used for the location of surface holes. The company employs a full-time geologist. Drill holes are located only after a target is indicated by careful study of both surface and underground geology.

For cost-accounting purposes, all diamond drilling is carried as exploration, and all drifting is carried as development. However, development accounts are carried under two headings: Exploration development and Stope development. At this mine the total cost of exploration is a significant part of the cost of mining.

The steps in searching for and developing an ore body are best illustrated by an actual example. For this purpose the "F" ore body in the Moore-shaft area has been selected (fig. 4).

On the basis of the ore exposed in the 200 stope on the 400 level West Hanging Wall drift (fig. 4), 2 diamond-drill holes (132 A and B) were drilled from the 500 level toward the downward projection of the favorable beds. One of these holes intersected ore along the east 90 fault. It first was believed that this ore might be connected with the 200 stope on the 400 level. Based on the information from hole 132 A, the 500 west footwall 320 crosscut was driven, and the 320 raise was driven into the ore. Some low-grade ore was mined from this 320 stope (fig. 5), then mining was stopped because of deficient grade.

Later, holes off the 400 level (holes 153 A, B, C, D, and E) and hole 160 A off the 420 sublevel stope in the "D" ore body indicated an ore body extending to the west from the 320 stope. Hole 157 was drilled downward from the 400 level to determine if the ore in the 400 level west 200 stope connected with the ore found in hole 132 A; also to help ventilate 500 west "F" 320 stope. A drift was driven northwestward under the inferred trend of this ore from the end of the 500 level 320 crosscut. Drill holes 166 A, B, C, and D, and 170 A, B, and C then were fanned upward, confirming the ore body. A sublevel drift then was driven westward from the 320 stope, and mining was begun.

SAMPLING AND ESTIMATION OF ORE

The occurrence of the ore bodies is very erratic, so sampling and estimation of ore reserves are difficult. Each ore body is a separate problem. An attempt is made to cut the ore body with enough drill holes to establish its size and shape (fig. 4). From this information, the volume is determined and converted to tonnage.

The core from all drill holes that pass through the ore body is split, and one-half is assayed. The assays of this ore are weighted, averaged, and used to estimate reserves. Where development headings pass through ore, samples are taken and assayed to determine grade. After a substantial production has resulted from an ore body, the known grade is considered in estimating the grade of the remaining ore in that ore body.

Records are kept of the number of cars and assays from each working place. These assays and the estimated tonnage on the basis of car counts, are corrected to the mill grade and tonnage at the end of each month. Broken ore is sampled on the

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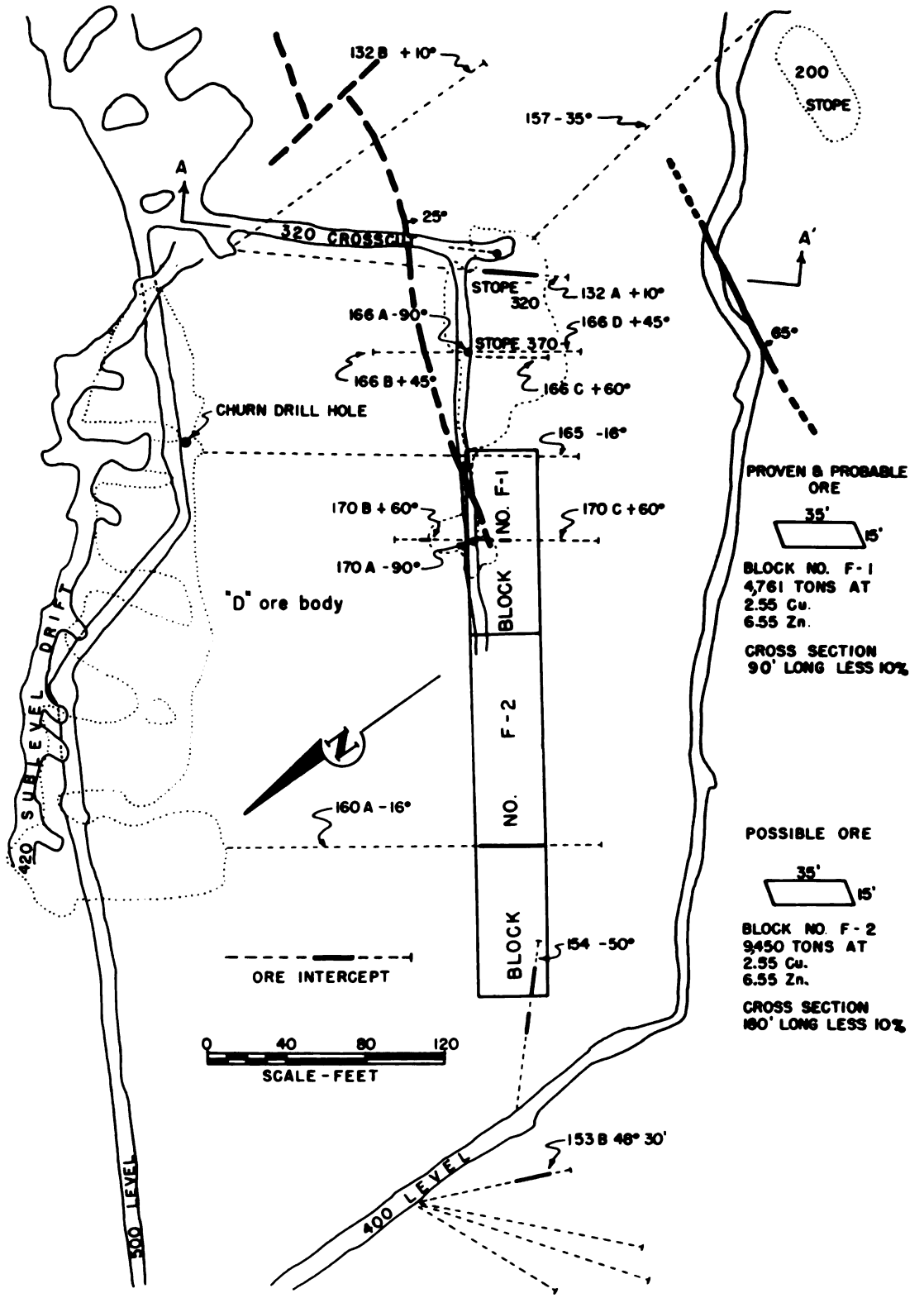

Figure 4. - Exploration drilling for "F" ore body.

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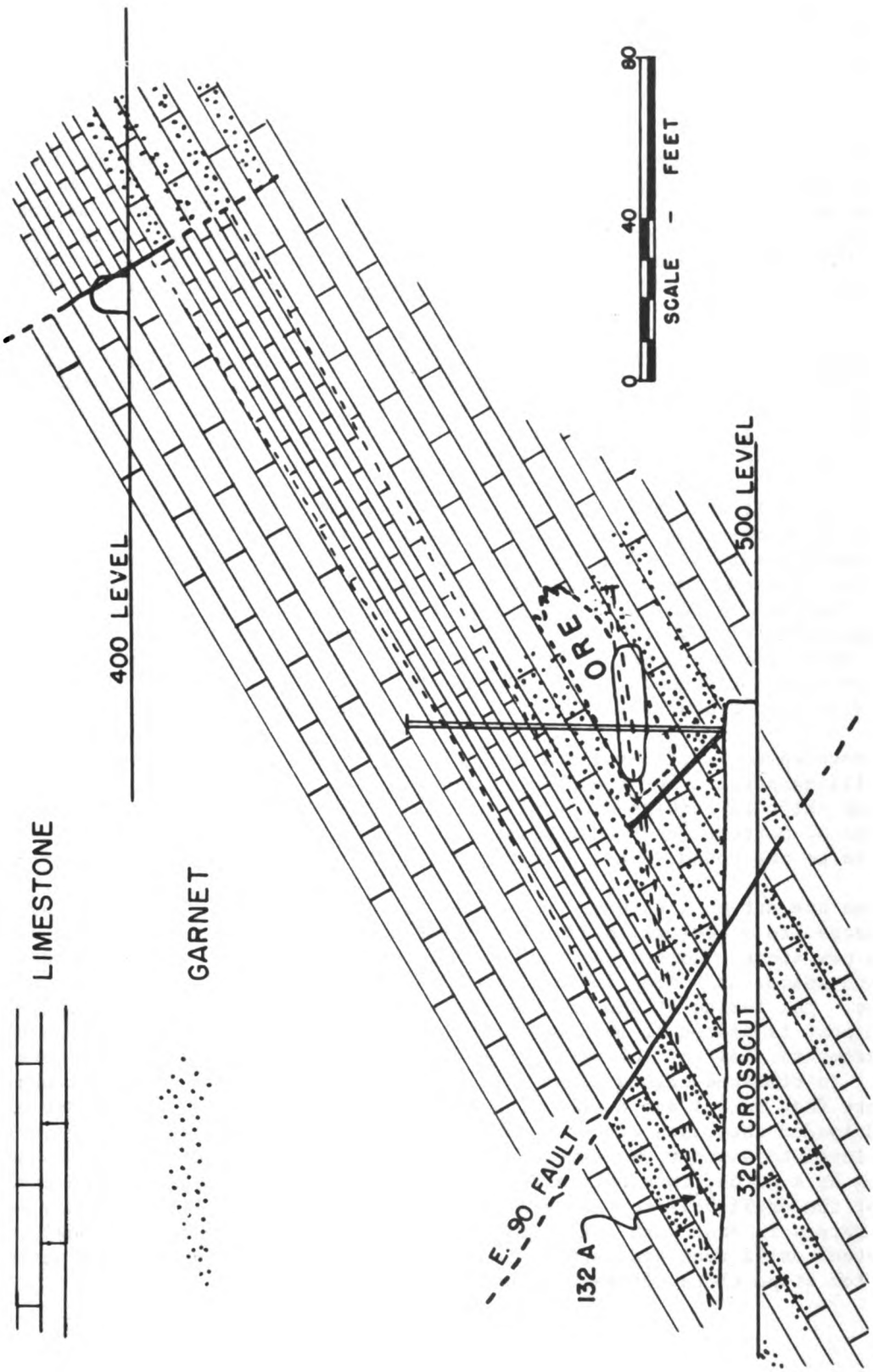

Figure 5. - Section through 320 stope.

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sublevel by the trammer, who takes a grab sample out of each car before dumping into transfer raises. The ore is sampled again by the haulage crews on the main levels for a check.

DEVELOPMENT

In the older workings of the district the ore was followed from the outcrop down along the slope of the favorable beds with an inclined shaft (fig. 6). The Republic area (fig. 7) is an example of this type of entry. This part of the mine is no longer in use. All production now comes from the Moore-shaft area (fig. 8), which has been developed by the 800-foot vertical Moore shaft. Three levels have been opened, and stopes are driven upward along the inclined ore bodies from these levels.

The Moore shaft has 2 hoisting compartments, each 4 feet 6 inches by 5 feet in the clear, and a 4- by 5-foot manway compartment. Level stations have been cut at points 380, 537, 651, and 751 feet below the collar. The shaft is timbered with 8 by 8 timbers, and level stations are timbered with 8 by 8, 8 by 10, and 6 by 8 timbers (fig. 9). The headframe is of steel construction.

From the shaft stations, development drifts 6 by 7-1/2 feet in cross section are driven along the hanging wall or the footwall of the favorable beds. Drilling in development headings is done by automatic-feed drifters mounted on vertical column and arm. Carbide insert bits and 1-1/8-inch round high-carbon steel drill rods are used. Mucking is done with mechanical rocker-type loaders. End-dump mine cars, holding approximately 0.9 ton, are used. Short turnouts are provided at intervals along the drift for empty-car storage. No timber is used except where bad ground is encountered in major faults. There timber sets, using 8- by 8-inch posts and caps, are spaced on 5-foot centers. Three- by twelve-inch backlagging is used.

All development drift headings are driven on contract. The company has no required drilling pattern but requires an average of 5 feet or more per round. One full 8-hour shift is required to drill a 28- to 30-hole drift round. Holes are loaded with 40-percent gelatin dynamite and fired with caps and fuse. The next shift mucks up the round, puts in track, and extends water, air, and vent pipe.

Raises are driven for three purposes: To transfer ore to a level below, to provide access to a sublevel at the bottom of an ore body, or to start the development of a new stope. Raises may have 2 or 3 compartments. Stulls (8- by 8-inch timber) are spaced at 5-foot intervals between compartments of very steep or vertical raises. The inside of the ore pass is lined with 3- by 12-inch lagging. A 4- by 6-inch post is placed at each end of the stull for a spreader. When the raise is two compartments, half of the manway compartment is used for hoisting timbers and supplies. In timbered raises a chute is placed on the level, and muck is drawn into cars. Very flat raises are driven without timber. The muck is scraped out on the level and loaded onto cars with a mucking machine. Where a raise is to be driven from one level to another, a diamond-drill pilot hole is drilled first. In addition to serving as a guide, this hole aids ventilation. Compressed air is connected to the top of the drill hole to remove smoke from the raise. Drilling in very steep or vertical raises is done with self-rotating stopers, using 1-inch, hexagonal, high-carbon, steel drill rods and carbide insert bits. In flat raises or for slabbing off to widen for stope slots, feed-leg mounted drills are used.

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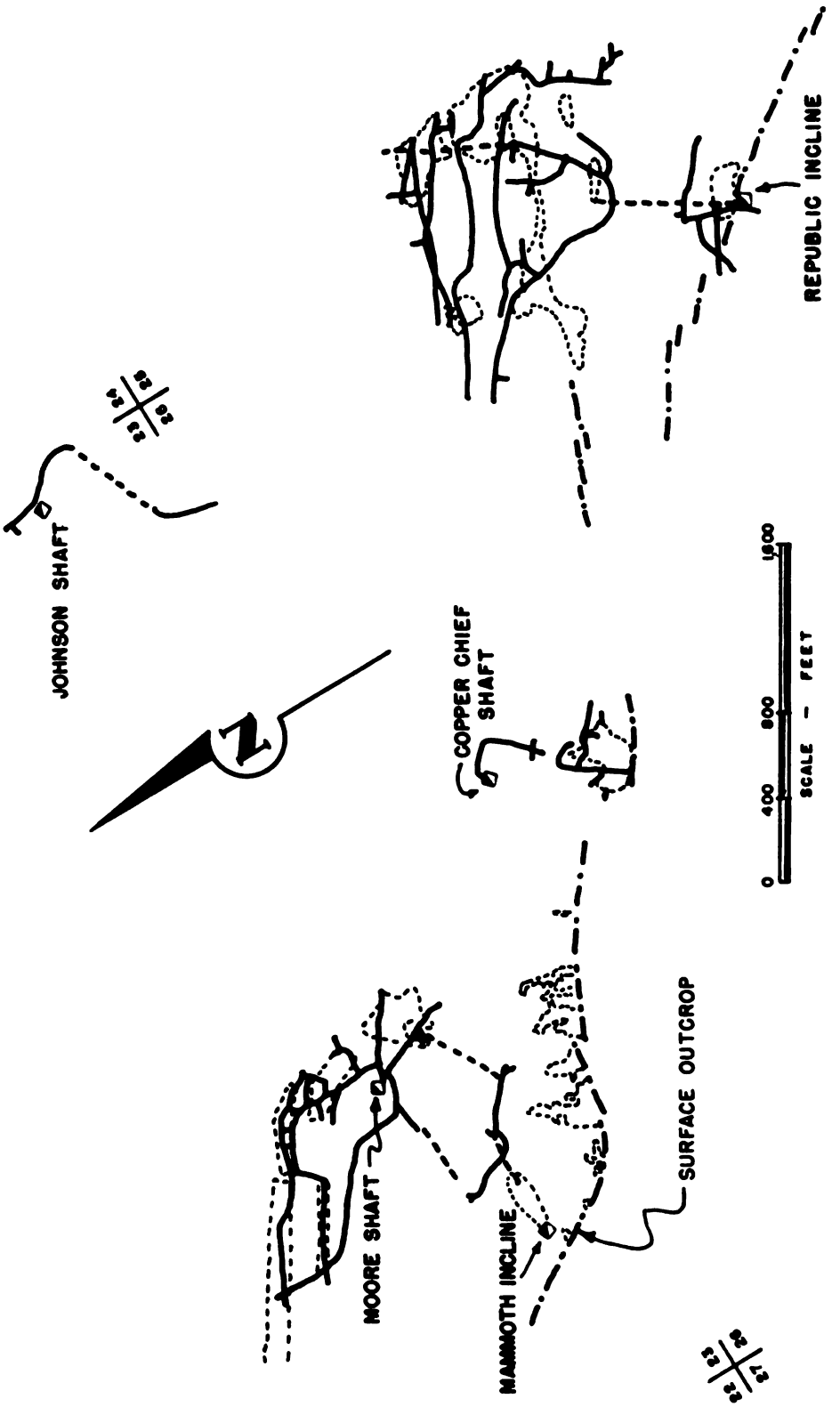

Figure 6. - Johnson Camp unit, underground workings.

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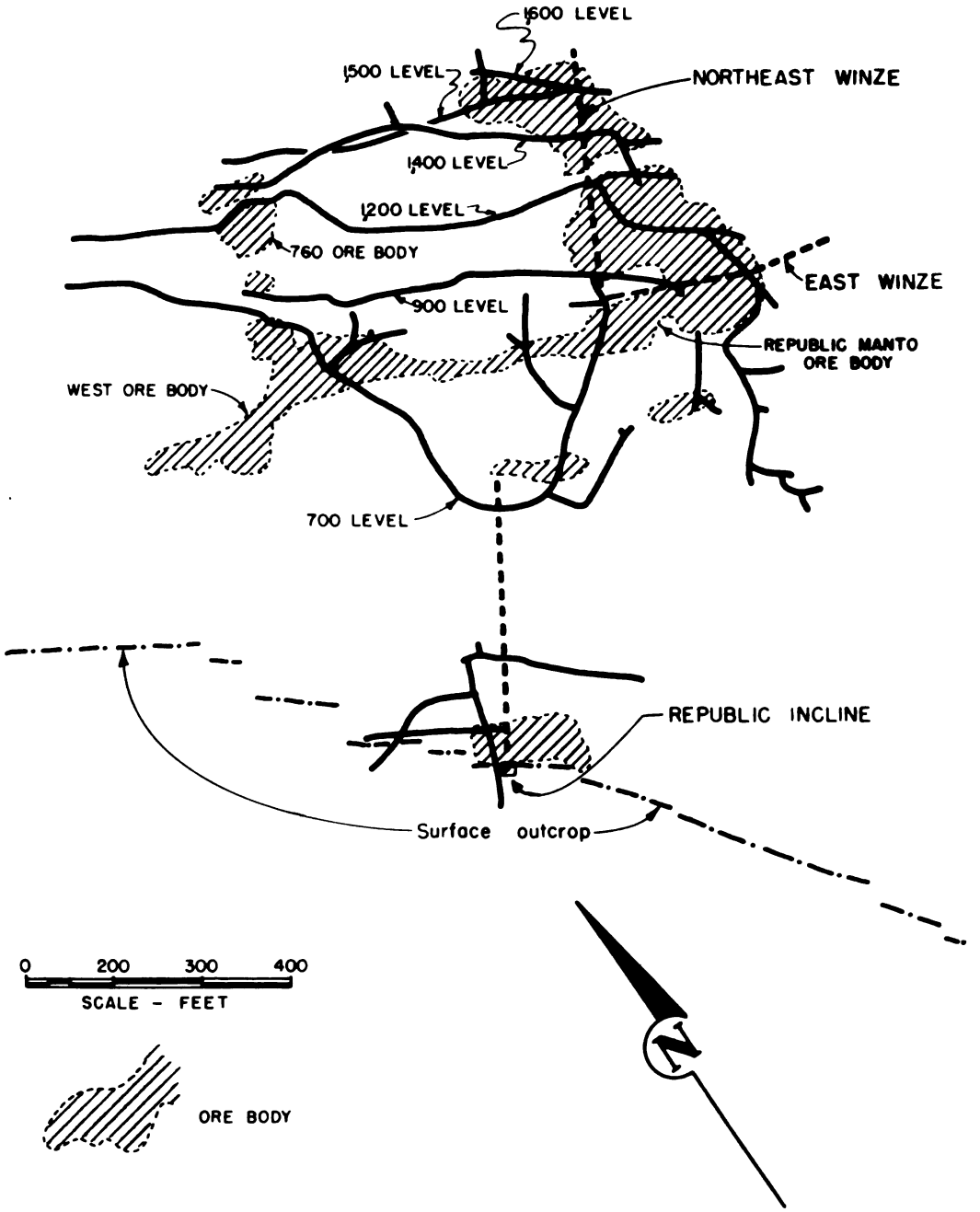

Figure 7. - Republic incline area.

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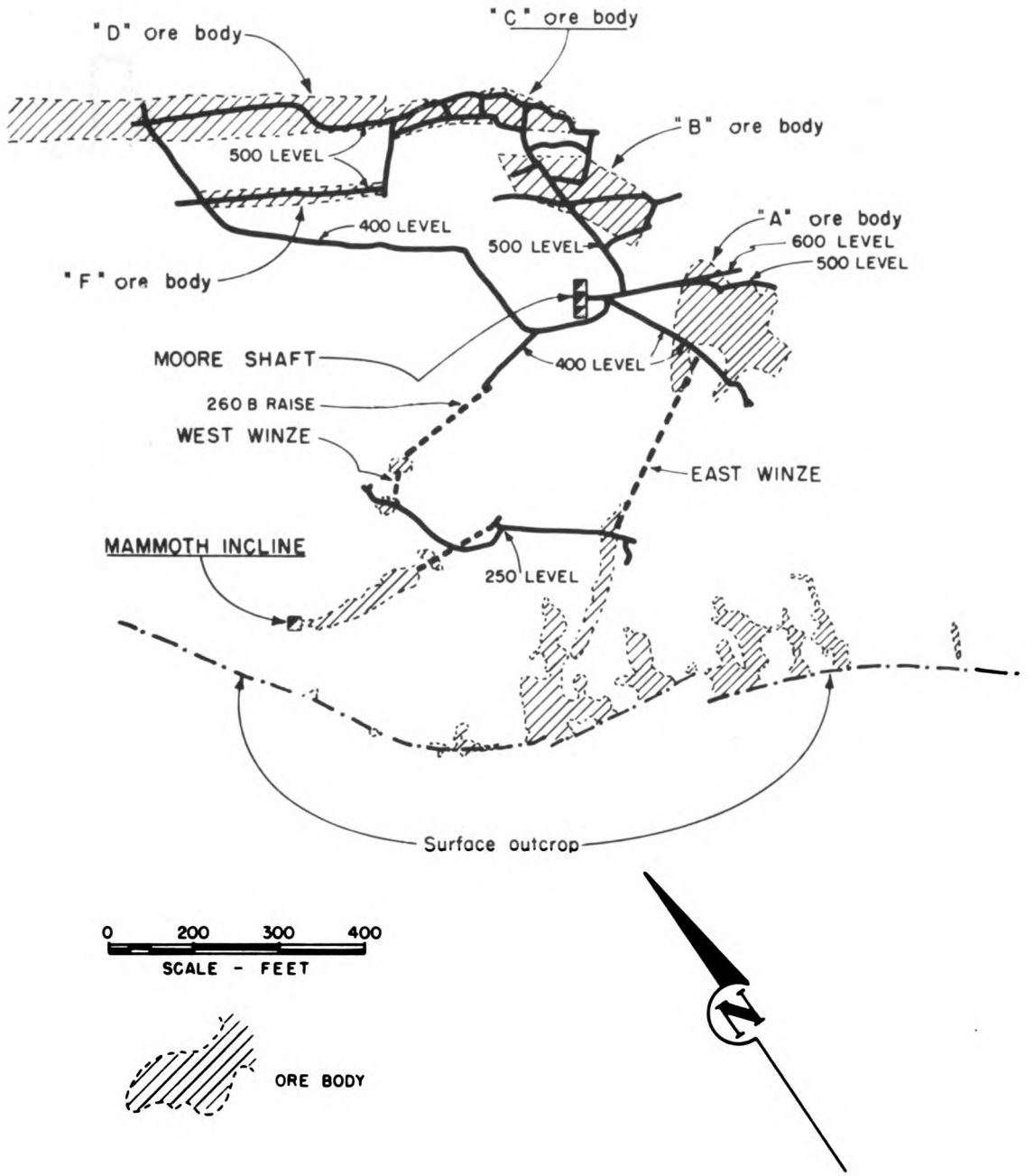

Figure 8. - Moore-shaft area.

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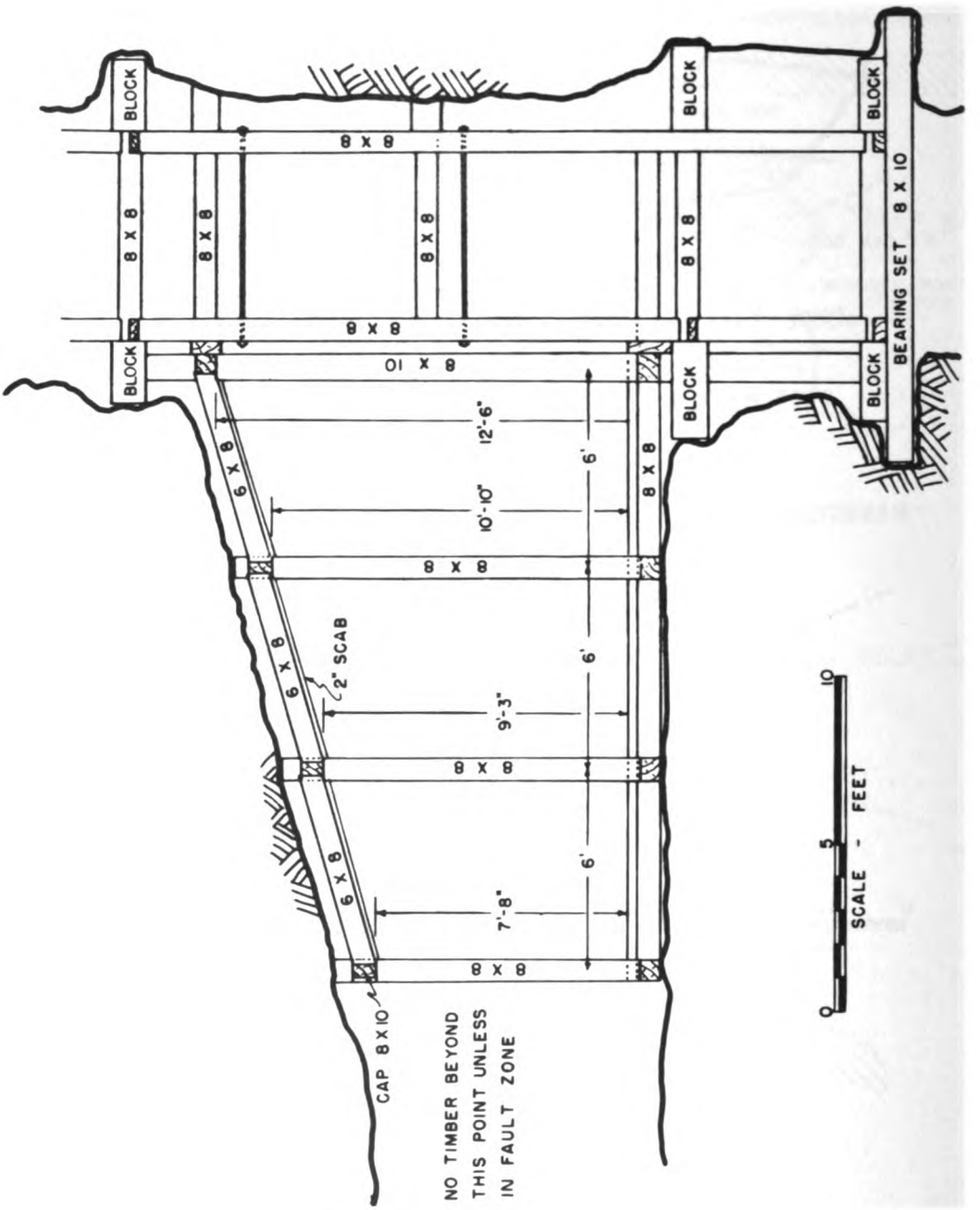

Figure 9. - Moore-shaft station timber.

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MINING (STOPING)

Except for one small, square-set stope in a small body of oxidized copper ore, the open-stope mining method is used. Pillars are left, and the back of the stope is rock-bolted. The ore is broken by loading and blasting longholes that are drilled from sublevel drifts. Pillars will be extracted after other ore has been mined.

The details of the method are modified to suit local conditions. A stope in the "A" ore body is illustrated in figures 10 and 11; here a drift was driven along the hanging wall in the ore. Stopes were laid out approximately 40 feet wide and normal to the strike of the ore body. Pillars 30 feet wide were left between stopes. From the hanging-wall drift a raise was driven just under the hanging wall and along the center of the stope to the top of the ore. This raise then was slabbed out to form a slot the full width of the stope. The back or hanging-wall side of the slot was scaled and 1-inch-diameter by 6-foot 6-inch roof bolts were installed on 4- to 5-foot centers.

From the 500 level, draw raises were driven and connected over the width of the stope. A footwall raise then was driven along the footwall at the center of the pillar on each side of the stope, and footwall sublevels were driven to connect these raises. These sublevels were spaced at 25-foot intervals. At the center of the stope a crosscut was driven from each sublevel to connect with the hanging-wall slot.

Using 3-inch automatic drills mounted on column and arm and 5-foot sectional drill steel with couplings, rings of holes were drilled from each sublevel crosscut to the side limits of the stope. Tungsten carbide insert bits were used. The maximum length of the holes was 35 feet. Each ring, with approximately 33 holes, was spaced 3 feet from the preceding ring.

In the first attempts ring holes were drilled both up and down; however, it proved to be difficult to clean the drill cuttings from down holes. The present practice is to drill long holes in an upward direction only, as illustrated in the typical drill-hole pattern in figure 12.

Two to four rings of holes were loaded with 60-percent gelatin dynamite and blasted, using millisecond-delay electric caps fired from the surface. The broken ore was picked up from a millhole on the 500 level by a mechanical loader, loaded into a 0.9-ton end-dump car, and hand-trammed 300 feet to the shaft station. Large boulders were placed to the side and blasted at the end of the shift. Primacord was used to connect and fire mudcap shots to break the boulders.

The "D" ore body (fig. 12) differs from the "A" ore body in that it is not as large, the updip cutoff is a fault, and the ore body has been cut by a number of the "Northeaster" faults. There are displacement and some oxidation along these faults, so they are left in the pillar wherever possible (fig. 13). The east 90 fault that forms the up-dip cutoff is from a few inches to 10 feet or more thick and dips 25° to 40°. The gouge along this fault is oxidized and has an adverse effect on mill recovery. This is the only part of the mine where dilution has occurred.

In the "D" ore body (fig. 12), after the hanging-wall drift has been driven for the length of the ore, a turnout drift is driven parallel to the hanging-wall drift and equal in length to the width of the stope. This ranges from 30 to 50 feet. From this turnout drift a raise is driven up the hanging wall along the center of the stope and widened out to the full width of the stope. The wedge of ore below

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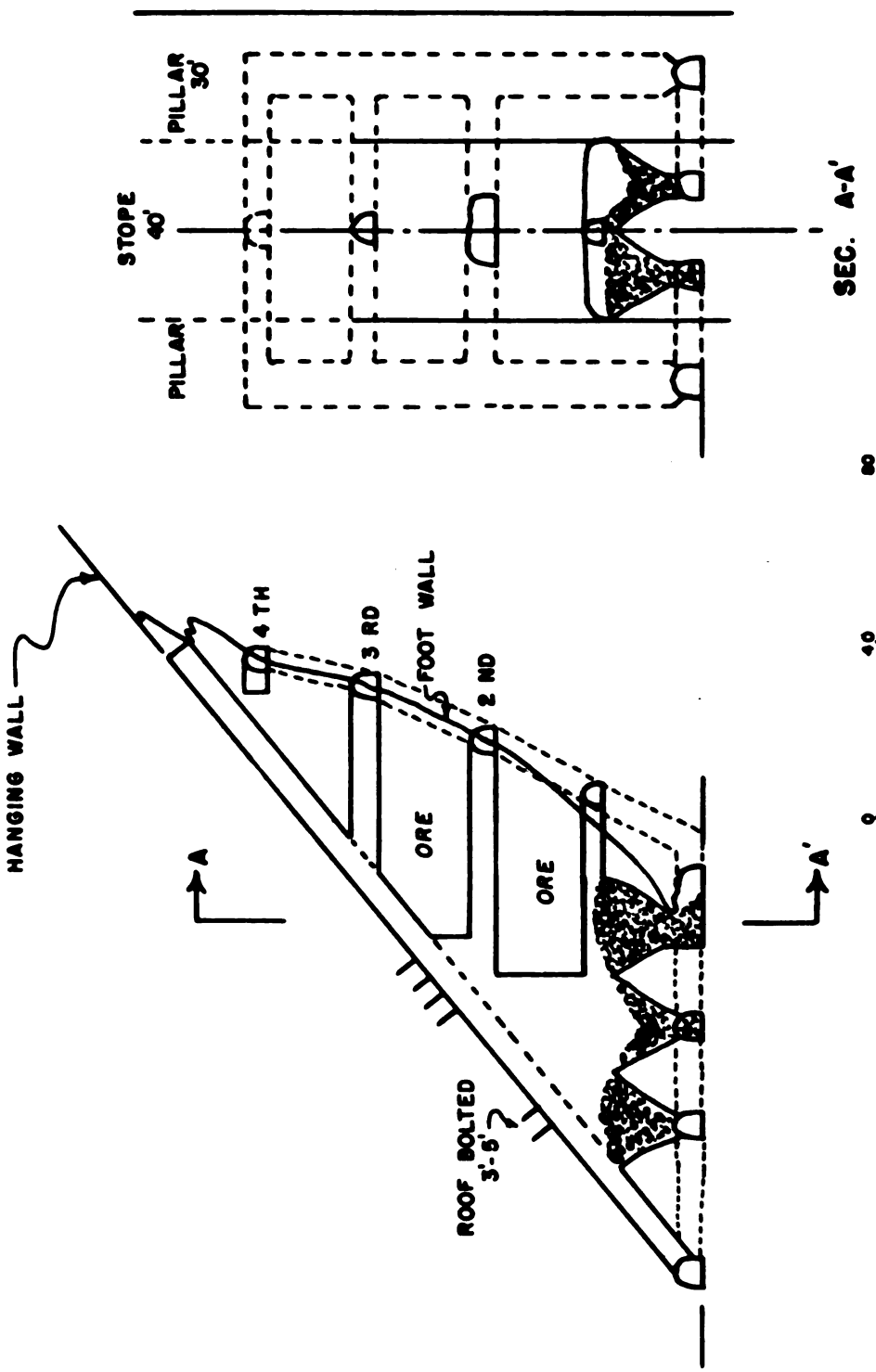

Figure 10. - Stoping method, "A" ore body.

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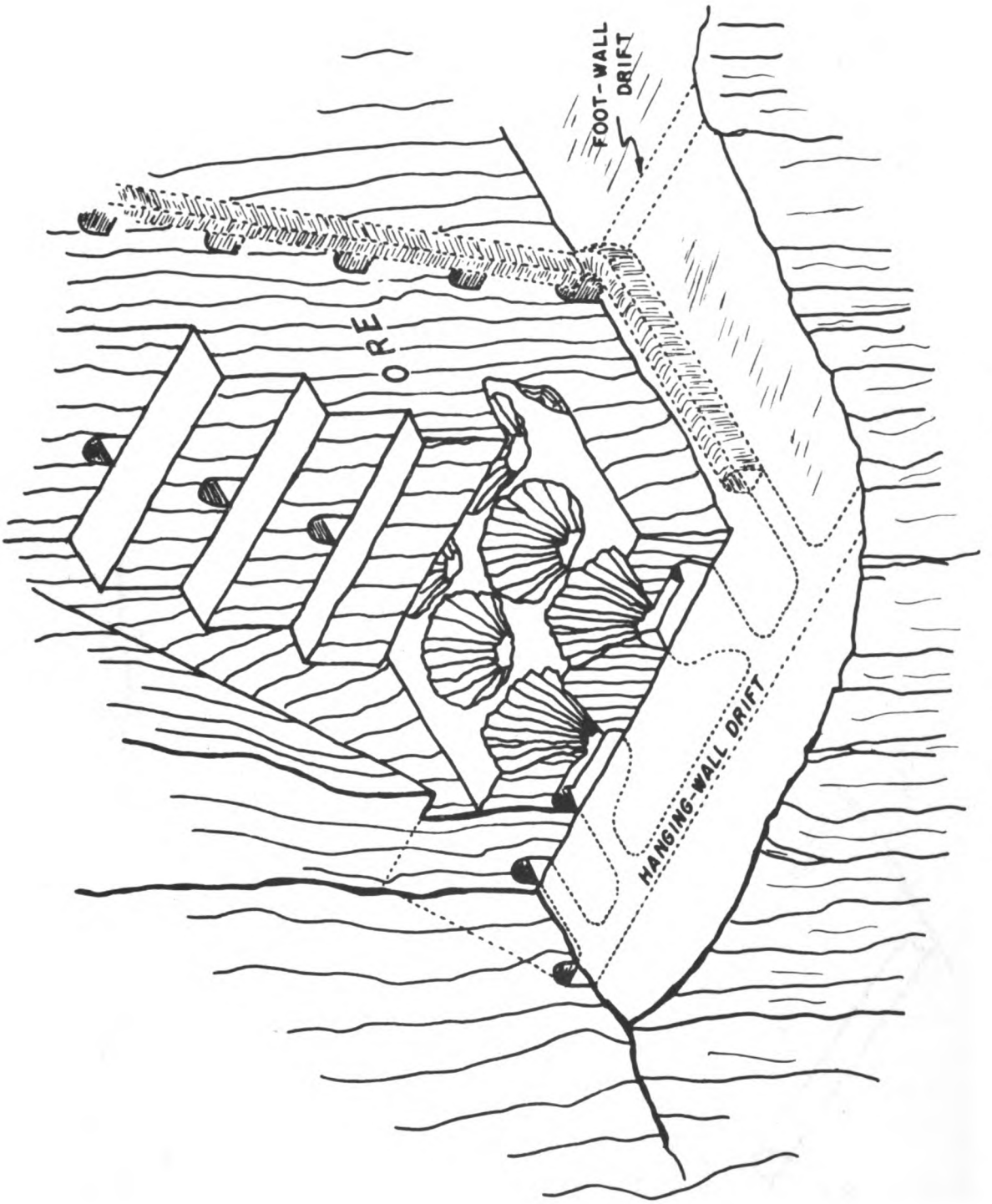

Figure 11. - Cutaway view of developed stope.

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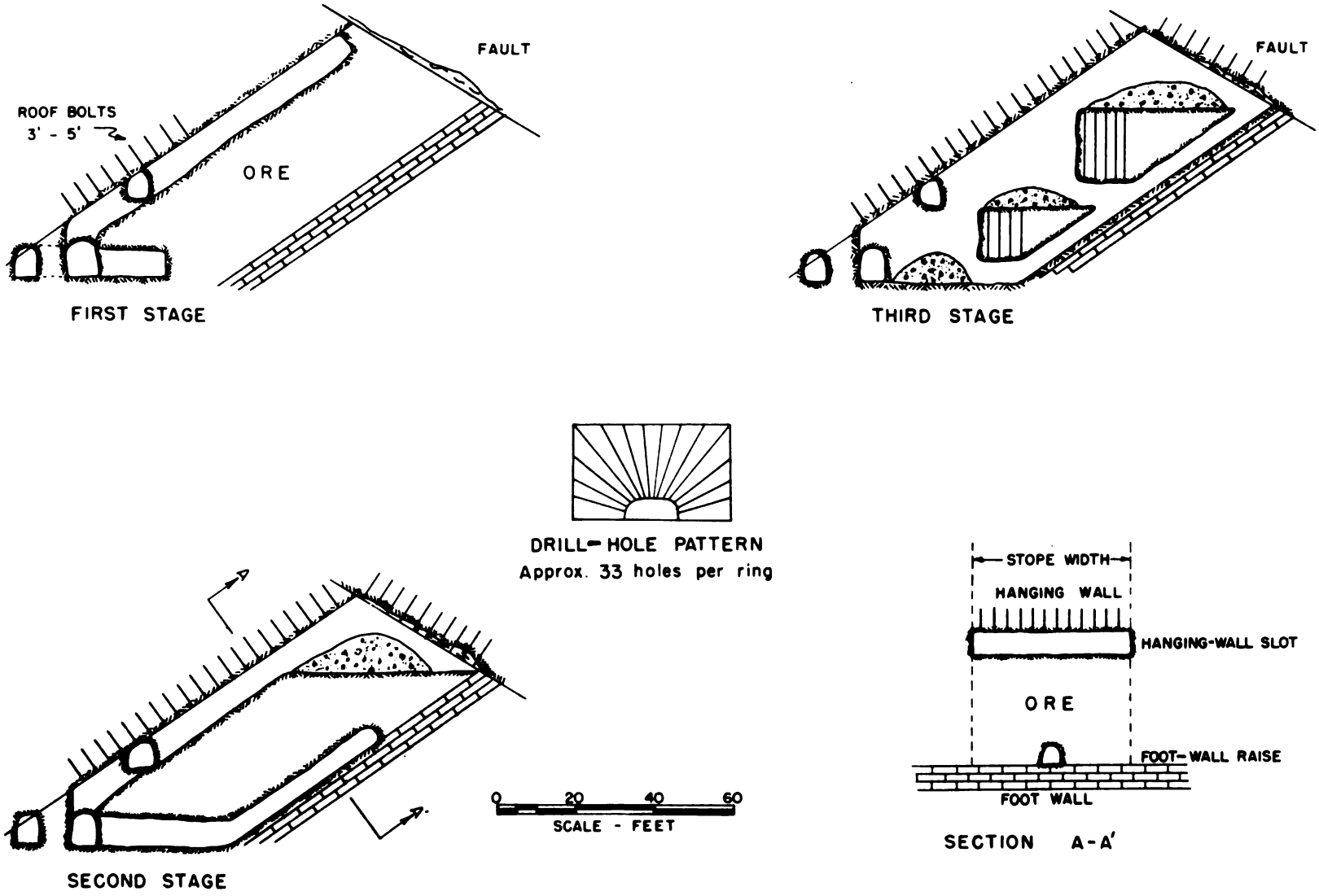

Figure 12. - Stages in development of a typical stope.

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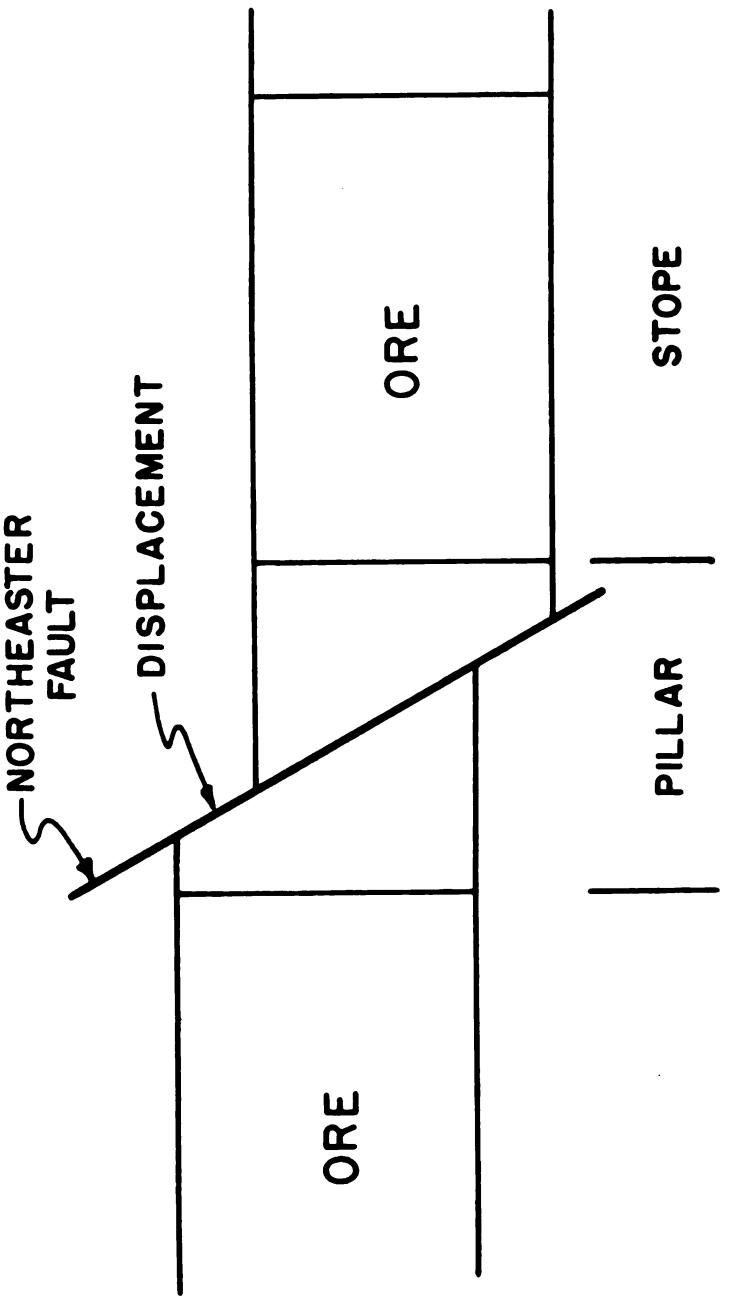

Figure 13. - Location of pillar with respect to northeast fault.

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the fault then is taken out, and where the fault forms the back of the stope, 1-inch by 6-foot 6-inch roof bolts are driven through the fault gouge into the rock above; the gouge is left in place. Where the fault is thin enough so the bolts go into the limestone above, no difficulty has been experienced in keeping the fault gouge in place; but where the thickness of the gouge exceeds the length of the bolts, some gouge has broken from the back and diluted the ore.

After the wedge of ore between the fault and hanging wall has been removed, a crosscut is driven to the footwall, and a raise is driven up the footwall to the fault. Crosscuts are driven from this raise to the hanging-wall slot and widened to provide room to ring drill. The muck is scraped to the main level, where it is loaded in cars by a mechanical loader and then hand-trammed to a transfer raise to the 500 level. Boulders too large to handle are set aside and blasted at the end of the shift.

TRANSPORTATION

Most ore is moved to the bottom of the stope by gravity. In some stopes the hanging wall is quite flat, so it is necessary to scrape ore from the hanging-wall raise and from the slot as the raise is widened. In the final stage of a stope it is desirable to collect ore with a scraper near a point where it easily can be loaded into cars or where it will fall in a raise. Double-drum 7.5-hp. hoists and 30-inch scrapers are used for this purpose.

When stopes bottom on main levels, as in "C" ore body (fig. 14), the ore is loaded into 0.9-ton end-dump cars with a mechanical rocker-type loader and trammed directly to the 600-level transfer raise. When stopes bottom on a sublevel, the ore is loaded into cars, trammed a short distance to a transfer raise, and dumped through to a haulage level. Cars are hand-trammed on the sublevels; they are made up in 10-car trains and pulled with a battery locomotive on the main levels. The 400 and 500 levels are used for haulage.

All track on both main levels and sublevels is 18-inch-gage, with 20-pound rails. At the shaft stations, tracks and switches are so arranged that cars can be caged with a minimum of delay (fig. 15). Each cage has two decks. Both decks are used to hoist muck, but only the top deck is used to hoist men. At the surface cars are dumped by hand into a 200-ton steel bin.

From the 400 level cars of ore and waste are caged and hoisted to the surface. However, from the 500 level ore is dumped over an 8-inch grizzly into a transfer chute to the 600 level, where it is loaded into cars, caged, and hoisted. This transfer requires handling ore an additional time but provides storage underground and prevents delay to haulage units when the hoist is not operating or is being used for other purposes.

SHOP AND AUXILIARY OPERATIONS

A small shop is maintained underground to provide facilities for repairing hoses and for small repairs to equipment. On the surface, a blacksmith shop, welding shop, machine shop, carpenter shop, and warehouse are maintained. Approximately 18 employees are required in these shops to service mine, mill, and townsite.

Powder is delivered to the mine by truck and stored in a magazine on the surface. Only enough powder is lowered into the mine each day-shift for that day. A small cap magazine is maintained underground for storing caps and fuse. The fuse is capped in 9- and 12-foot lengths.

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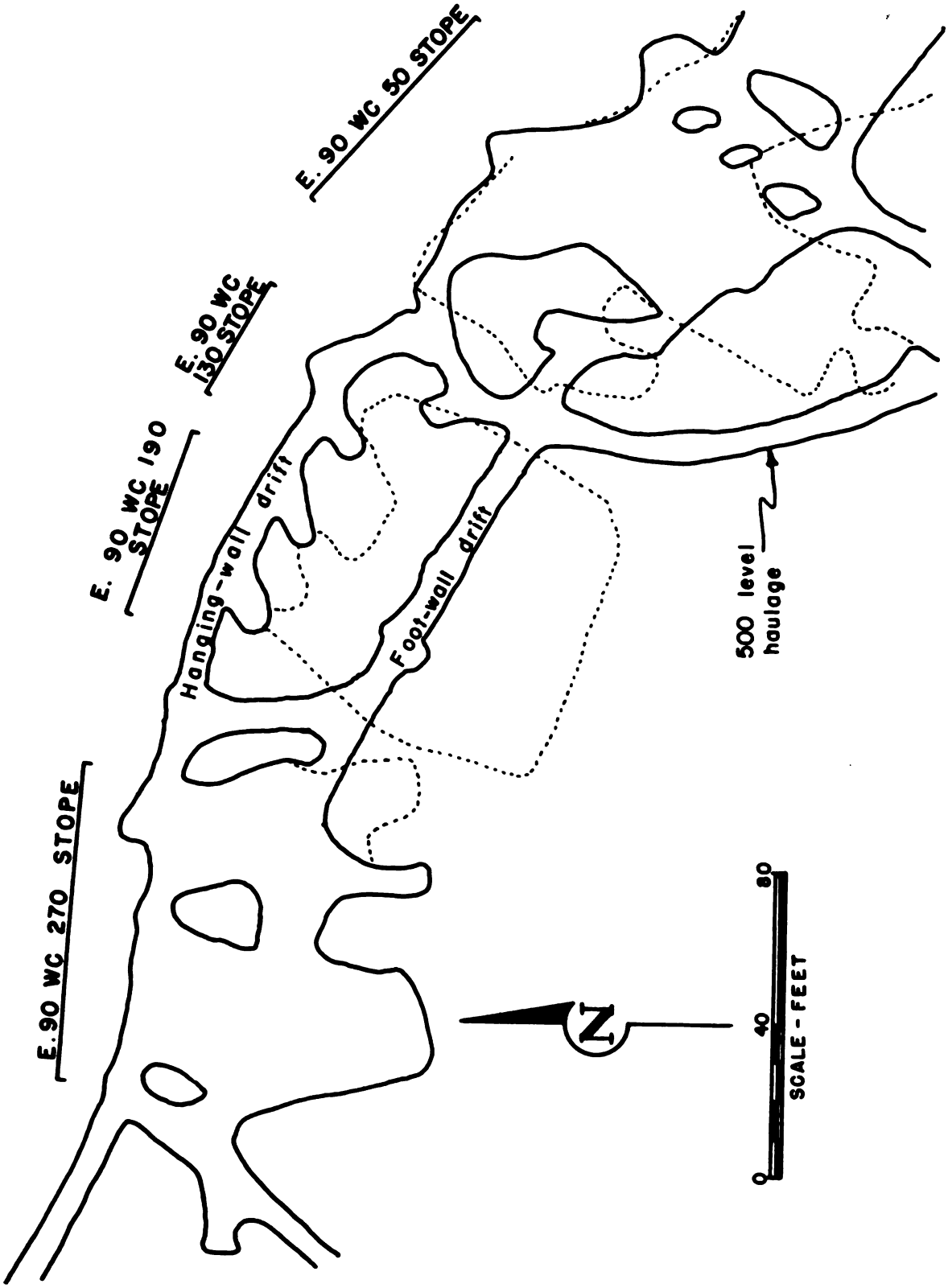

Figure 14. - Stope arrangement, "C" ore body.

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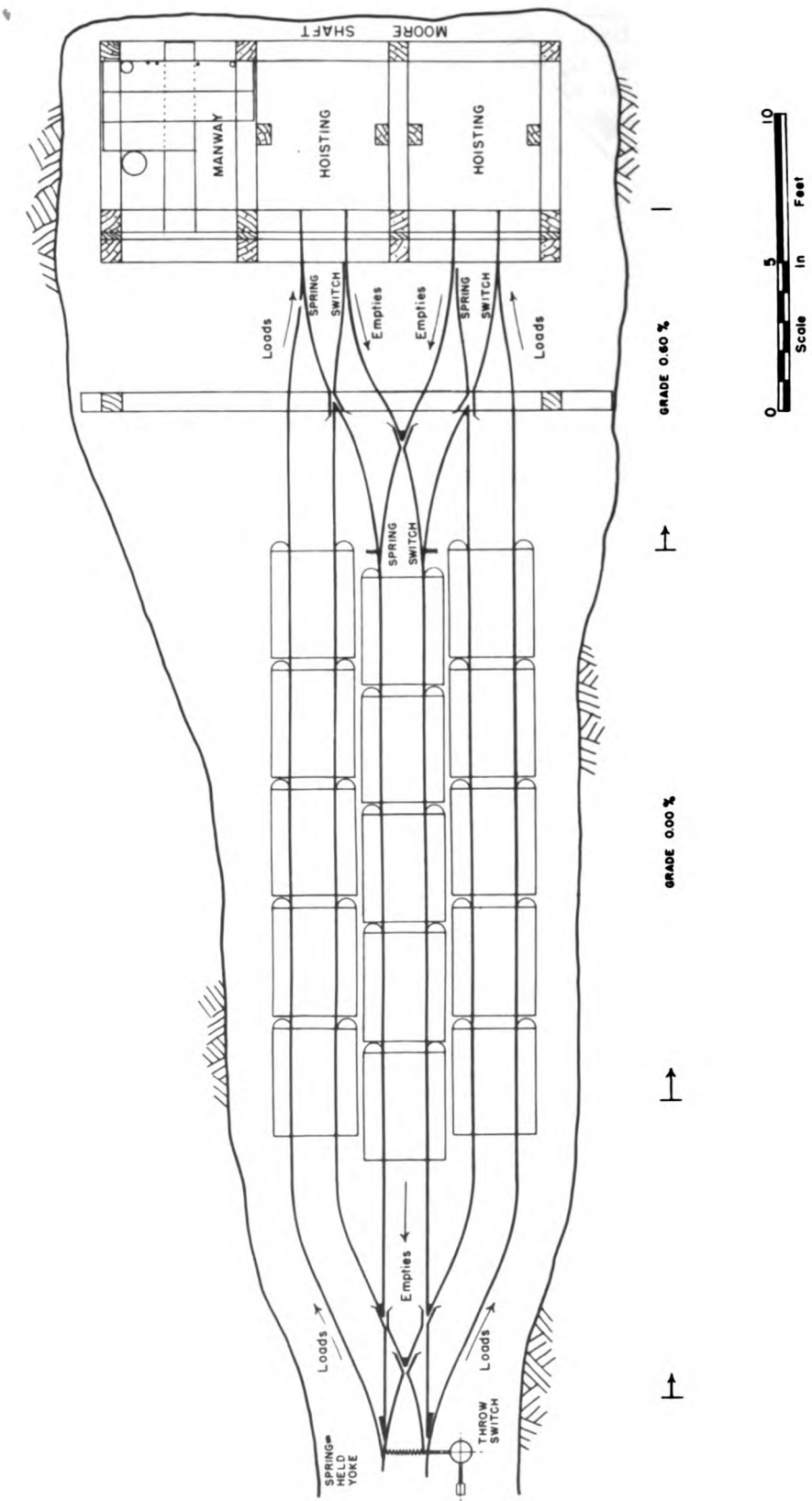

Figure 15. - Station layout for caging cars.

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A hoisthouse, compressor building, and changehouse are near the collar of the Moore shaft. A battery-charging station for Edison cap-lamp batteries is in one corner of the hoist building. A double-drum hoist powered with a 200-hp. electric motor designed for a rope speed of 800 feet per minute is in use. The improved plow steel rope used is 1-1/2-inches in diameter, 6 by 19 regular-lay preformed with fiber core.

Four compressors provide compressed air that is piped down the manway compartment of the Moore shaft and distributed to the working places. They include two 15- by 9-1/4- by 12-inch compressors with 100-hp. motors, one 20- by 12- by 16-inch compressor with 150-hp. motor, and one 17- by 10- by 12-inch compressor with 125-hp. motor.

From the surface bin (fig. 16) the ore is loaded into 8-ton dump trucks and hauled approximately 1 mile to a 15- by 17- by 10-foot bin of wood construction at the crushing plant.

Power is purchased from REA. The mine and mill have a connected load of 1,885 hp. About 400 hp. of this connected load normally is not used, as it consists of compressors and hoists at the currently inactive Republic shaft. Power costs about 1-1/4 to 1-1/3 cents per kw.-hr.

The company owns and provides 35 dwellings for employees with families. Three bunkhouses and a boarding house are operated for the convenience of single men. Some employees live in Willcox or Benson and drive back and forth to the mine. A county school bus takes children to the Cochise Grammar School and Benson High School.

EXTRACTION

None of the ore bodies in the Moore-shaft area has been mined completely. Present plans include mining a large part of the ore in the pillars. A high percentage (possibly 90) of extraction is anticipated.

Wherever possible, development headings are driven in ore, and waste production is held to a minimum. The waste produced is gobbed in an empty stope when possible; otherwise, it is hoisted to the surface.

VENTILATION

The Moore shaft and the Mammoth incline are connected. The collar of the Mammoth incline is approximately 100 feet above that of the Moore shaft. This condition causes a natural draft that reverses direction as the seasons change. An airplane-propeller-type booster fan is on the 400 level. The 15-hp. motor on this fan is so wired that it always turns in a direction to aid the natural ventilation. Small auxiliary fans are used in long development headings. The "D" ore body was mined from a sublevel, 55 feet above the 500 level. As there was no connection between the 400 and 500 levels, an 18-inch churn-drill hole was put down from the surface to provide fresh air to the stopes. A fan on the surface, driven by a 10-hp. motor, forced air down this hole. The average temperature over the mine is about 66° F., and the relative humidity is about 92 percent.

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Figure 16. - Moore-shaft headframe.

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MINE DRAINAGE

Water collected below the 500 level is accumulated in the shaft sump and pumped to a sump on the 500 level by a deep-well turbine pump driven by a 50-hp. motor. Water from above the 500 level collects in the same sump. From this sump, water is pumped to a tank on the surface by a 4-stage centrifugal pump powered by a 40-hp. motor. Water flows by gravity to the mill. The mine produces water at the rate of about 100 g.p.m.

Domestic and mill makeup water is pumped from 2 wells in Sulphur Springs Valley 8.5 miles east of the mine and 800 feet lower in altitude. The pumping plant is comprised of 2 duplex pumps driven by a 30- and a 40-hp. motor.

BONUS SYSTEM

A bonus system of payment is in effect for driving all development headings, longhole drilling in stopes, and underground diamond drilling. Payment for driving drifts in on the "unit" basis, with the rate set at $8 to $10 per foot. Payment for driving raises is on the "unit" basis, the rate depending on the size of the raise, type of timber, and inclination.

In the long-hole drilling and underground diamond drilling, a standard number of feet per shift is established. For any advance over this standard, a bonus per foot is paid.

SAFETY MEASURES

Fire extinguishers are hung at all places in the mine where electric motors are operated. The company maintains two mine rescue teams. These teams and first-aid classes are instructed at regular intervals by a member of the District H, Health and Safety Division, of the Federal Bureau of Mines. The company owns 45-minute breathing apparatus and has access to 2-hour apparatus.

The regular foremen are responsible for safety inspections.

MILLING AND PRODUCTION

The mill was designed for a capacity of 150 tons per day. The actual capacity is 217 tons. The flowsheet is shown as figure 17. The equipment is listed in table 1, and the reagents used are listed in table 2. Tailings are stored in a pond near the mill. Water is not reused. Concentrates are trucked to Dragoon, a station on the Southern Pacific Railroad. Copper concentrate is shipped to the International Smelting & Refining Co. Miami smelter, and the zinc concentrates are shipped to the Bartlesville smelter of the National Zinc Co.

Milling is continuous 7 days per week. A mill operator and a flotation operator constitute the working force on each of three shifts. On day shift, 1 man operates the filter plant, and 2 men operate the crushing plant.

A copper concentrate containing 27 to 31 percent of copper and a zinc concentrate containing 52 to 56 percent of zinc are made. No return water is used, as it has an adverse effect on flotation. About 4 tons of water is used per ton of ore.

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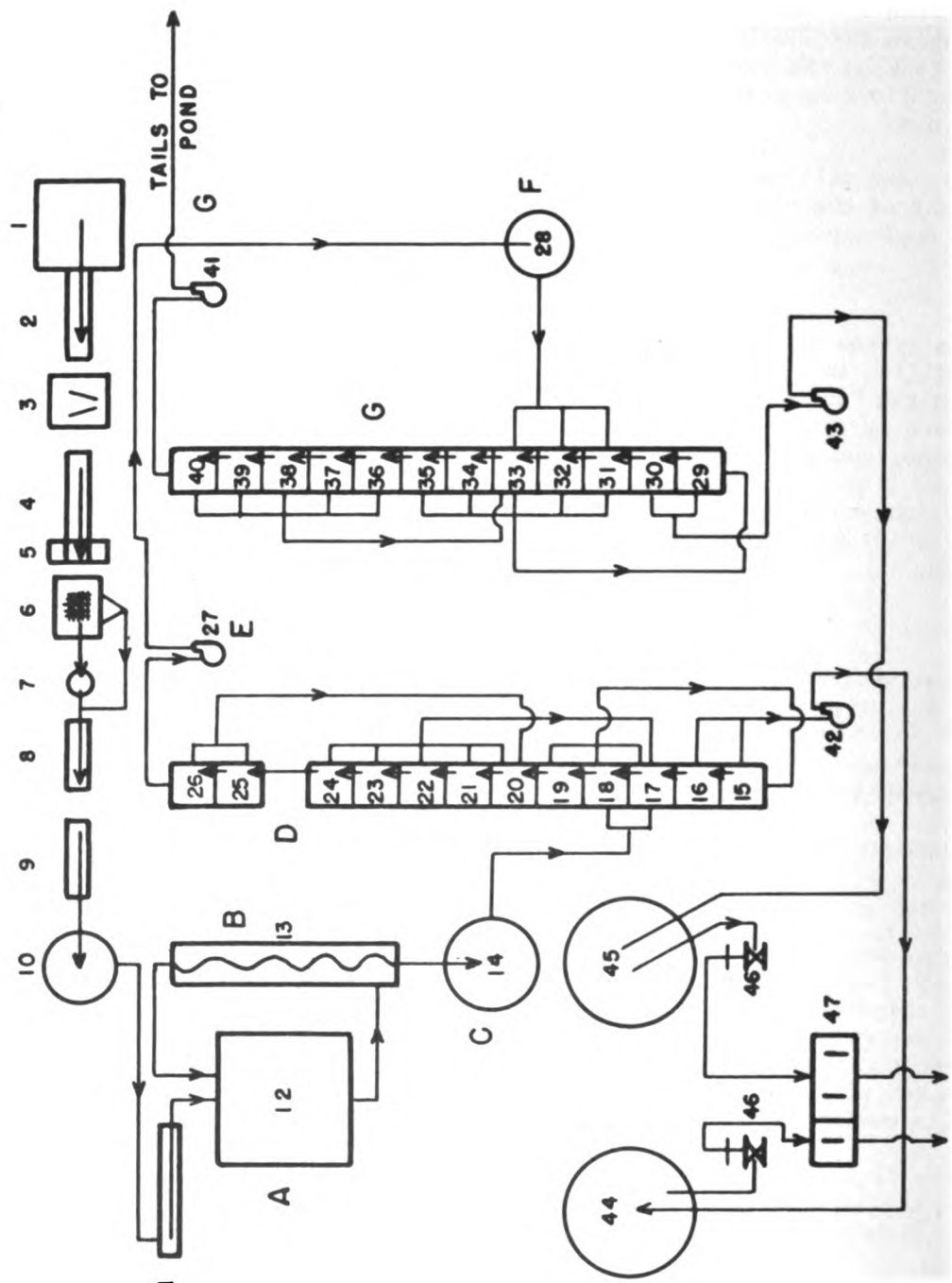

Figure 17. - Mill flowsheet.

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The recorded production of the mine follows:

Year	Ore, tons	Production, pounds[1/] Copper	Zinc	Year	Ore, tons	Production, pounds[1/] Copper	Zinc
Before 1947	Unknown	33,000,000	15,301,000	1952	77,748	3,305,900	7,384,900
1948	67,150	1,936,700	5,749,300	1953	76,836	3,484,700	7,181,300
1949	37,566	1,377,200	3,519,900	1954	75,673	3,374,500	6,728,800
1950	21,823	996,200	2,050,400	1955	73,311	3,298,200	5,803,900
1951	64,654	2,700,000	6,486,000	Total	494,761	53,473,400	60,205,500

1/ Figures before 1947 are from Arizona Bureau of Mines, Arizona Zinc and Lead Deposits, Part I. Figures for 1948 through 1951 are from Bureau of Mines Minerals Yearbooks. Figures for 1952-55 are from company records. Some silver also is recovered from the ore.

TABLE 1. - Concentrating-plant equipment
(Numbers refer to fig. 17)

1. Wooden truck bin 15' x 17' x 10'
2. Pan conveyor 42" x 36'
3. Jaw crusher 13" x 24"
4. Conveyor 16" x 89"
5. 24" magnetic pulley
6. Vibrating screen, double-deck 3' x 6'' 1-1/2" and 5/8" openings
7. 3' standard cone crusher, fine
8. Conveyor 14" x 56'
9. Conveyor 14" x 194'
10. Steel storage bin 15' x 30'
11. Conveyor 14" x 27'
12. 6 x 8 ball mill
13. 48" x 19' spiral classifier
14. 6' x 6' conditioner
15-24. 15" mechanical flotation cells
25-26. 24" mechanical flotation cells
27. 2" centrifugal pumps (2 used)
28. 6' by 6' conditioner
29-32. 15" mechanical flotation cells
33-40. 18" mechanical flotation cells
41. 2" centrifugal pumps (2 used)
42-43. 1-1/4" centrifugal pumps
44. 8' x 18' thickener
45. 10' x 20' thickener
46. 4" diaphram pumps (2 used)
47. 6' - 3 disk filter

TABLE 2. - Reagents used in concentrator
(Letters refer to fig. 17)

A. Calcium cyanide
Thiocarbonilid 130
Zinc sulfate
B. Pine oil
C. Z-8, methyl isobutyl carbinol
D. Pine oil, Z-8
E. Lime, minerec 201, methyl isobutyl carbinol
F. Z-8, copper sulfate
G. Ferrous sulfate

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